Vegetation Resources Inventory

Implementation Strategy to Integrate Management, Provincial and National Inventories

MINISTRY OF FORESTS
RESOURCES INVENTORY BRANCH
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FORWARD

The Ministry of Forests, Vegetation Resources Inventory (VRI) Program is an improved process for assessing the quantity and quality of British Columbia's timber and other vegetation resources. This system replaces BC's previous process of assessing timber resources.

The following document describes the general approach the Ministry of Forests (MOF) is following in implementing this program.

We strongly support the continued implementation of the VRI program and encourage those involved in using forest resource information to support this important initiative.

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EXECUTIVE SUMMARY

This paper discusses the use of the Vegetation Resources Inventory (VRI) Resources Inventory Committee (RIC) Standards as the basis for defining minimum collection requirements for Management Unit, Provincial and National Forest Inventory and coordinating the interest in baseline data collection from three different inventories in a combined VRI approach. The inventory unit for the management inventory consists of any division of interest, such as a Tree Farm License (TFL) or Timber Supply Area (TSA) or specific vegetated strata such as problem forest types. The management unit inventory measures selected resources in specific geographic portions of the Districts. The inventory unit for the Provincial Inventory is the province, however, for ease of management it is implemented on one or more Forest District(s), as defined by the MOF. The National Forest Inventory (NFI) measures timber and non-timber vegetation resources in the province and develops its own set of summary statistics.

Management unit inventories are the responsibility of the stakeholder(s) such as the TFL Licensee or Forest District. They are usually timber-emphasis inventories that provide detailed polygon information for improved overall TSA and inventory related information for day-to-day forest management. The Provincial Inventory is expected to provide data for landscape unit, sub-regional and provincial inventory planning and reporting, monitoring and research. The baseline data is needed to address credibility and public relation issues relevant to the forest industry in BC. It also reduces the pressure on TFL holders to provide data for rolling-up to the provincial level. The NFI will provide information on provincial resources across all provinces allowing the Federal Government a consistent framework for reporting Canada's inventory.

Independent implementation of the three levels of inventory would produce three estimates of timber volumes for each unit. While each estimate serves a specific purpose, these three volumes need to eventually be reconciled by replacing the less precise estimate with the more precise estimate.

A coordinated approach to implementing the inventories will be pursued. By preparing Inventory Implementation Plans, stakeholders will identify their business needs and the inventory strategy to be employed to meet those needs. Coordinating the inventories at this level will ensure that the needs of each stakeholder can be met in a cost-effective manner.

The NFI and Provincial Inventory in each District can be implemented in parts called *implementation units,* which could be a management unit such as a TSA or TFL. This would involve planning for the inventories in advance, and subdividing the national and provincial ground sample plots into management units. Completion of the Management Unit, Provincial and National Inventory ground samples to minimum standards would then be undertaken at the convenience of the groups responsible for each implementation unit. The MOF (assisted by licensees) is responsible for installing the NFI and Provincial Inventory plots in the TSAs, Parks, and on private land. The TFL or Forest License licensees would assist by installing the Provincial and National plots on their TFLs or operating areas. This approach provides flexibility in terms of administration, funding, and timing.

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1. INTRODUCTION

1.1. BACKGROUND

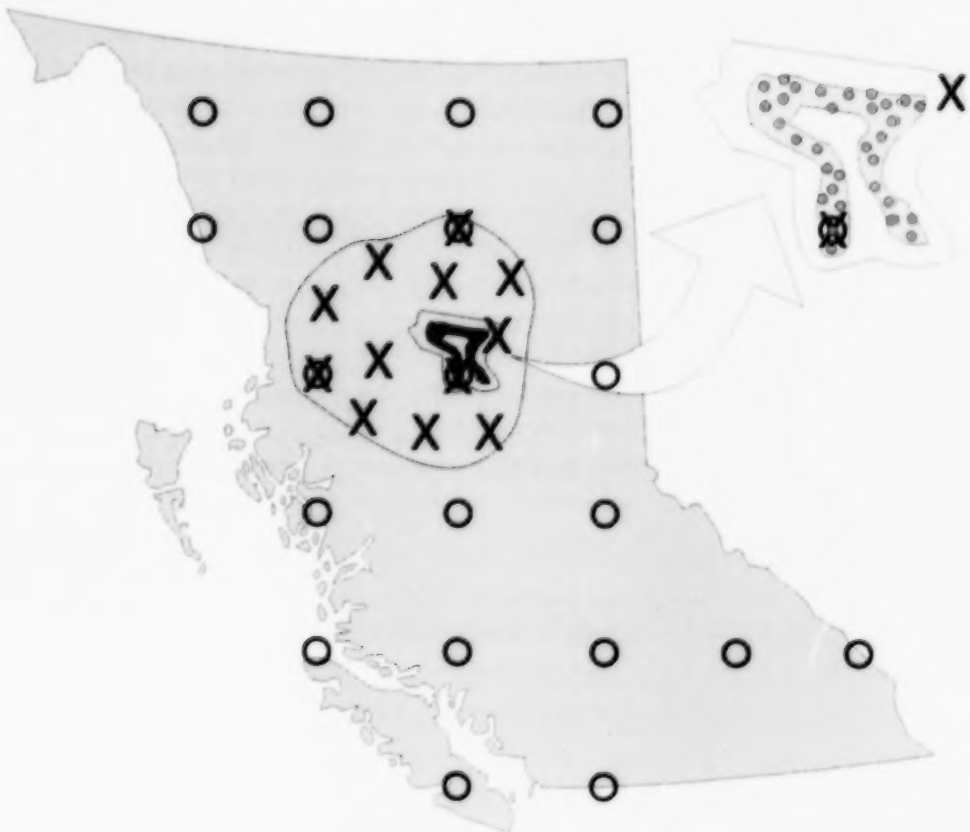
The Provincial Vegetation Resources Inventory (VRI) is an improved vegetation inventory process that has associated tools for assessing the quantity and quality of BC's timber and other vegetation resources. The VRI process replaces and improves on the existing British Columbia forest cover inventory. The VRI consists of polygon delineation and estimation through photo interpretation, ground sampling, statistical adjustment methods designed to estimate overall population totals and averages for some timber and non-timber attributes, and polygon averages and totals.

Deployment of the VRI over the entire province (one or more Forest Districts at a time) will be referred to as a *Provincial VRI* in this paper. The Provincial VRI can be implemented by different groups in each District. These parts are called *implementation units*. An implementation unit could be a management unit (e.g., Timber Supply Areas (TSA), Tree Farm License (TFL)) or a portion of it (e.g. problem forest type). Inventory information from all the implementation units in a District is combined to calculate District totals, which in turn are rolled up to the provincial totals. The VRI can also be deployed as a *Management Unit Inventory* over a large management unit (e.g., a TSA or TFL) or a small watershed, to upgrade existing management inventories by measuring selected resources in specific portions of the landbase. The minimum VRI collection requirements or standards are identified under separate headings within this document.

There is a third level of inventory referred to as the National Forest Inventory (NFI). The NFI will cover Canada, however, its implementation will be conducted by province or territory. The NFI will be implemented on a grid basis as compared to the polygon basis of the Provincial VRI or the Management Unit Inventory. The National Forest Inventory's information requirements are compatible with those of the Provincial VRI.

The three identified levels of inventory (Management Unit, Provincial and National) each address specific business objectives. However, there is concern about the cost effective and operational integration of these inventories.

Three Levels of Inventory in BC



Key:

O = National Forest Inventory

X = Provincial Vegetation Resources Inventory

• = Management Unit Inventory

1.2. DOCUMENT OBJECTIVES

The objective of this document is to provide stakeholders interested in conducting a Management Unit or implementation unit of the Provincial VRI with a framework and planning guide. As such, this paper discusses:

- Management Unit Inventories;
- The Provincial Vegetation Resources Inventory;
- The National Forest Inventory;
- Minimum standards for inventory data collection;
- Integration of the inventory ground samples; and
- Inventory planning and sign-off requirements.

2. MANAGEMENT UNIT INVENTORIES

2.1. OVERVIEW

Management inventories include inventories conducted in management units, and in sub-units (portions of management units), to fulfill specific forest management or business needs. Sampling error and sampling intensity are controlled for specific vegetation attributes (e.g., timber volume) to achieve specific inventory objectives. There are several types of management units in the Province: Timber Supply Areas (TSAs), Tree Farm Licenses (TFLs), and other lands (Parks, private lands, and other public lands). Within (or across) these management units there may be sub-units addressing specific issues, such as Problem Forest Types in the operable forest land base.

2.2. OBJECTIVES

Management Unit Inventories are typically defined as timber emphasis inventories. Besides providing detailed polygon information for day-to-day forest management, they can also be used to increase precision of the Provincial inventory. As such, they must comply with VRI standards and minimum information requirements as defined by the Ministry of Forests (MOF).

The stakeholder(s) (e.g. TFL holders, licensees or the MOF Regions/Districts) is (are) responsible for the planning and implementation of these inventories. However, the MOF Resources Inventory Branch requires the stakeholder to prepare an Inventory Implementation Plan, which includes identifying the business objectives and a sampling plan. An Inventory Implementation Plan defines the inventory needs, the information needed to meet the needs, and the methods for collecting the information. This implementation plan then drives the inventory for the given unit.

2.3. INVENTORY UNIT

The inventory unit for a Management Unit Inventory is a unit or stratum defined by the stakeholder(s). For example, the unit could be a whole TFL, a geographically defined part of a TFL or a stratum of concern within the TFL such as low site hemlock leading stands. The definition varies depending on the stakeholders business needs.

2.4. ACTIVITIES

The Provincial VRI and/or Management Unit Inventories may involve either new photo interpretation or upgrading existing photo interpretation to VRI specifications followed by ground sampling. Ground sampling activities include establishing ground sample clusters, Net Volume Adjustment Factor (NVAF) sampling, and Within Polygon Variation (WPV) sampling. The ground sample clusters (usually 50-200) are established over the entire landbase of one or more Forest Districts, by implementation units. They are used to collect information on trees, ecology, and range. NVAFs are used to adjust net volume from the ground sampling (derived from the net factoring process and taper equations) to account for hidden decay and possible taper equation bias. WPV data enables the estimation of individual polygon inventory error using the variation between the true values of an entire polygon and the measurements from the single cluster of sample plots.

Activities required for a Management Unit Inventory are defined in an Inventory Implementation Plan. Such activities may involve improving the polygon delineation and estimation through photo interpretation, as well as ground sampling. Management Unit Sampling designs may involve the use of sampling designs more intensive than those of the Provincial VRI. However, it is important that the Management Unit Inventories use the relevant VRI standards, definitions, and measurement protocols. The primary advantages of adopting VRI standards and procedures in TFLs, TSAs, and other areas include seamless integration of Management Unit Inventory data with Provincial VRI data, and ease of data sharing, production of integrated baseline inventory to support information development to address resource issues and resource management credibility.

One component of the VRI is sampling for NVAF. NVAF is used to statistically adjust the estimated net volume for an Inventory Unit. It is calculated as a ratio of actual net merchantable volume, which is based on felled tree sampling, to the estimated net merchantable volume, which is based on the CG/NF (call grading/net factoring) system and the MOF taper equations. It will correct for possible taper equation error; CG/NF rule error; hidden decay and hidden loss indicators. NVAF factors replace the current loss factors. As there is no regional NVAF database yet available, unique NVAFs will be required for each management unit.

2.5. COMPILING THE MANAGEMENT INVENTORIES

Management Unit Inventories may be compiled using procedures similar to those used for the Provincial VRI, or other appropriate methods. Management Unit Inventories should not be adjusted based on the

Provincial VRI plots that are outside the respective management unit; however, the provincial plots within a management unit should be used to supplement the management inventory.

3. PROVINCIAL VRI

3.1. OVERVIEW

The Provincial VRI is an improved vegetation inventory classification and database development procedure, where the products are a spatial polygon map and database, and a ground plots database. Associated with the VRI are inventory processes for assessing the quantity and quality of BC's timber resources[1]. It was designed by inventory specialists from government, industry and academia, and has been approved by the BC Resources Inventory Committee (RIC). The RIC objectives are to develop a common set of standards and procedures for provincial resources inventories.

The VRI design is simple, reasonably efficient, statistically defensible, and addresses issues raised by the Forest Resources Commission in its 1991 report, *The Future of Our Forests*. Concerns raised by the Forest Resources Commission included:

- lack of statements of precision of the existing inventory;
- inadequate information on non-timber vegetation;
- lack of reliable estimates of growth rates and stand-specific volumes;
- lack of inventories in Parks and other reserved areas; and
- the narrow focus on commercial timber volume and the timber harvesting landbase.

3.2. OBJECTIVES

The VRI suite of tools is used to achieve the following Provincial Inventory objectives:

1. Produce the baseline VRI inventory product which is the VRI attribute polygon data base and associated summary statistics, namely unbiased overall averages and totals for timber and non-timber vegetation resources for the entire landbase, for provincial annual reporting. The Provincial VRI will provide the Chief Forester with a range of timber and non-timber baseline attribute data and information of known precision to support decision making, and furnish the general public with a level-of-comfort that the inventory information is accurate. Provision of baseline and summary information addresses the concerns expressed by the Forest Resource Commission.

[1] There are other applications that use information from the VRI within their production cycle such as determining wildlife habitat. However, these processes will not be the focus of this document.

2. Provide a statistically valid framework for monitoring forest resources, by providing the initial conditions and locations for measuring changes and trends in timber and non-timber information. The initial condition, change, and trend data will support the National Inventory and can also be used to provide a province-wide statement of sustainability of forest practices[2]. This monitoring information can be used to maintain the quality of BC's forestry practices, to enhance BC forest products markets, and to address public environmental concerns. No reliable estimates of change and trend data can be obtained from the existing management unit inventories. Erroneous information can be obtained when apparent differences arise from changes in methodology, terminology, area of coverage, or from replacing an old inventory with a new one[3].
3. Provide baseline data to confirm District biodiversity guidelines and non-forest classification.
4. Provide core VRI baseline attribute data to support the development of information on non-timber resource values. Examples are VRI-derived ecosystem and habitat mapping, and the generation of plant lists. The former is basic information for land management to increase public credibility on forest operations. The latter would help indicate where more intensive sampling could improve estimates for specific plants (e.g., medicinal plants) and other botanical products.
5. Provide common sampling locations and field procedures that can be used to measure a variety of other resources, special projects, and management inventories. The plot locations are established in an unbiased way and are re-locatable to allow re-visits.

The Provincial VRI is a provincial responsibility that is expected to provide baseline data to support forest land management planning, provincial inventory reporting, and research. Provision of VRI integrated baseline data helps to address credibility and public relations issues relevant to the forest industry in BC by providing the basis to develop a wider range of inventory products such as ecosystem and habitat mapping.

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[2] Criteria and indicators of sustainable forest management were defined by the Canadian Council of Forest Ministers (CCFM) in their 1995 report *Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators* (Natural Resources Canada, Canadian Forest Service, Ottawa, Ontario. 22 pp). The MOF has established a 20 km square grid (approximately 2,370 points) over the entire province, as part of the network of plots for the Canada national forest inventory. (It is also part of the provincial 100 m square grid used in VRI sample selection.) Photo plots will be established at each grid intersection, and ground sampling will be done in a sub-set (200) of the grid intersections as part of the District VRI. Provincial grid plots and plots established for VRI are the same where they exist. Ground sampling will follow the VRI measurement protocols. The purpose of the national forest inventory is to provide data for the Criteria & Indicators process, and data for national and international inquiries. The intent is also that data from this grid can be used to provide interim broad summary statistics for provincial inventory reporting until the District-by-District Provincial VRI is complete. Therefore, this grid can be considered an integral part of the Provincial VRI, and not a separate level of inventory.

[3] Barker, J., M. Bonnor, D. Gilbert, A. Omule. 1996. *A New National Inventory for Canada: The Need is Now!* Forest Chronicle. Vol. 72(3):276–279.

3.3. INVENTORY UNIT

An inventory unit is normally defined as the target population from which samples are chosen and to which the results are applied; for the Provincial VRI, the *inventory unit* will be the entire provincial landbase. However, for convenience it has been decided to implement this VRI in smaller parts consisting of one or more Forest Districts. These smaller parts, which will be sampled separately, are defined as *Inventory Units* for purposes of the Provincial VRI. The intent is that individual inventories would be summed to provide overall provincial totals.

Division of the province into several parts was recommended for several reasons[4].

1. The inventory needs to be undertaken on priority areas in a manageable sequence.
2. To provide valid information in local areas using only ground measurements taken in that area.
3. To allow recompilation and re-inventory of units without having any effect on other inventory units.
4. To allow for changes in technique over time, as experience is gained with the inventory process.
5. To allow sub-sampling or re-sampling on areas of relatively small size if important definitions or measurement protocols were to change.

The inventory unit (Forest District) can be further subdivided into parts such as management units. The purpose of management units is to assemble areas that should be sampled together as a logical working unit, for the convenience of sampling, or to achieve specific inventory objectives. Results from all the management units within a District are then combined to calculate District totals, which in turn are rolled-up to provide provincial totals.

3.4. ACTIVITIES

Activities for the Provincial VRI have been identified in Section 2.4.

[4] Iles, Kim. (Undated). *Vegetation Inventory by Parts. The Logic for Dividing an Inventory into Partial Units, To Be Completed by Different Groups or at Different Times.* Contract report for Ministry of Forests, Resources Inventory Branch, Victoria, BC.

3.5. COMPILING THE VRI

Compiling the Provincial VRI data involves rigorous statistical analysis[5], which includes:

1. Statistical estimation of overall inventory attribute values. These values include totals and averages for continuous attributes, and error matrices for categorical variables, for the inventory unit. This step answers the question "How much?".

2. Statistical adjustment, which is the process of assigning values to individual polygons such that their total (or error matrix) for the inventory unit matches that obtained in #1. This step answers the question "Where is it?".

These statistical analysis results in overall inventory unit totals and individual polygon-adjusted values that form the Provincial VRI databases. This step links photo interpretation with the ground sampling phase of the VRI, and the outputs from this step form the official VRI database. This is the core baseline VRI product.

Information from the ground sampling component can also form the basis for monitoring growth, yield, volume and decay. Studies are currently underway to examine the possibilities of monitoring response to silvicultural treatments and concluded that silviculture surveys be upgraded to VRI standards. It is anticipated that many questions regarding green-up, application of OGSI, etc., can be assessed through queries against a good second growth inventory.

4. NATIONAL FOREST INVENTORY

4.1. OBJECTIVES

The purpose of the National Forest Inventory (NFI) is to "...assess and monitor the extent, state and sustainable development of Canada's forests in a timely and accurate manner". More specifically, it should provide data for the Criteria & Indicators processes to monitor sustainable development, and data for national and international inquiries (for example, FAO/ECE Forest Resource Assessments). The NFI should also provide a framework for collecting data on other criteria and indicators (e.g. socio-economic indicators), and for studying the factors affecting forest health (e.g. insect attack, disease infestation, pollutant deposition) and productivity. Finally, it should be sufficiently flexible that the implementing agencies (the provinces, territories or their assigned delegates) can integrate the design into their existing or planned inventories in a cost effective manner.

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[5] Methods for the statistical analysis of the VRI data are currently being developed.

4.2. Inventory Unit

The population for the NFI is all of Canada. All potential sample locations reside on a national 4 x 4-km network. The preferred sampling intensity is a 20 x 20-km grid of sampling points (the 20 x 20-km grid is nested within the national 4 x 4 km grid). The 4 x 4-km network is intended for selections of sample locations (systematically or at random) for NFI reporting. The grid of sampling points may be replaced by other statistically defensible sampling systems (e.g., stratified random sampling) for large areas (e.g., a province or a stratum), as long as the required data will be obtained. This option makes it possible for provinces or territories which already have statistically based re-measurable inventories (Quebec, Nova Scotia) to use them for the NFI, possibly with some modifications.

The population will be stratified and reported by Terrestrial Ecozones, a national system of ecosystems classification. Sampling intensity will vary in the ecozones: it may be decreased in some arctic ecozones that have little or no vegetation, and increased in ecozones of particular significance or subject to significant changes; some (arctic) strata may not be sampled, only areas given. The population will be stratified by province/territory but will not be reported by province/territory unless approved by the province/territory. Stratification by province/territory is necessary since considerable variation can be expected among provincial and territorial designs and sampling intensities. Thus, the strata of the NFI are likely to be combinations of ecozones and provincial/territorial boundaries. This is not expected to present a significant compilation problem. There are approximately 250 ground plots required to fulfill BC's commitment to the NFI.

4.3. ACTIVITIES

Where the NFI network is used, sample locations will be selected from the 4 km network (for example, every 10^{th} point along the rows and columns of the network). Sample size may be varied with stratum to make the inventory cost efficient.

The basic design of the new plot-based NFI is to sample approximately 1% of the forested landbase using a combination of permanent air/remote sensing and ground plots. Satellite imagery will be used in (arctic) areas with little or no vegetation. Air photos will be used in treed and other vegetated areas. Both satellite imagery and air photos may be used in the inventory: a relatively intensive sample of satellite plots (to assess presence or absence of vegetation) is followed by a sub-sample of (vegetated) air photo plots. The third phase would be field sampling.

The National Forest Inventory design recommends a minimum of 50 forested ground plots per ecozone with no sampling planned for the Arctic ecozones. More intensive sampling will be required to meet provincial objectives. Sample locations are selected at random. Whenever the random allocation is permanently non-treed, it is 'rejected' and a substitute is chosen again at random. The rejected locations maintain their status as NFI ground plots, and although no measurements are taken, they contain valuable information and are retained in the analysis. Measurements of ground plots should be synchronized with the interpretation of photo plots. Attributes and data collected in ground plots will complement and

enhance the attributes and data from the photo plots.

The general approach is to have an on-going national forest inventory (as opposed to, for example, a periodic inventory where all plots are measured in a given year(s)). For an inventory with a 10 year cycle: 1/10 of all sample units (remote sensing and field) are re-measured every year following a statistically defensible design. The required attributes are re-measured, differences between the estimates made on the two occasions are compiled, and appropriate statistics are calculated.

4.4. COMPILING THE NFI

Each province and territory will compile per-ha statistics for the sample units and submit to the Canadian Forest Service (CFS) together with other relevant statistics. A data model for these purposes will be developed by the CFS. The CFS will compile stratum and population statistics (means, totals, variances) for the attributes with the first national summary based on this design to be ready by 2005.

5. MINIMUM STANDARDS FOR VRI DATA COLLECTION

The VRI is an inventory classification system for a number of attributes, and a system of protocols that produces databases that can be managed through a dispersed computing environment. The VRI classification and data development process can be used to meet today's needs for timber supply, long term planning, silviculture planning, defining sustainability, public information and credibility. The VRI can also provide data for computer modeling and decision support systems to support a baseline biodiversity assessment and for research.

Depending on the need for information as defined by the stakeholder, data can be collected using one or more of the Provincial VRI processes. Completing the Management Unit, Provincial and National Inventories to RIC standards will ensure that:

a) Vegetation Resources Inventory data is consistent across the province for reporting purposes;
b) Vegetation Resources Inventory data meets the needs of the Chief Forester; and
c) Clients who use the VRI data will have a clear understanding of that data.

Minimum standards for inventory data collection are required for all levels of inventory information and must be consistent with the Resources Inventory Committee (RIC) standards. Changes to the VRI standards can be requested through the Vegetation Inventory Coordinator care, of the Resources Inventory Branch, MOF. Requests will be addressed through their Change Management Process on an annual basis.

The following sections outline the minimum standards for data collection for the components of the VRI being implemented within Management Units and for the Provincial VRI. These standards are compatible with the National Forest Inventory.

5.1. PHOTO ESTIMATION

The VRI Photo Estimation process is designed to provides a polygon database consisting of various vegetated and non-vegetated attributes. The database and its associated mapping products provides the spatial baseline data on vegetation and ecological characteristics within British Columbia. This baseline data is collected to provide resource managers with information for landscape unit planning, strategic planning and broad based decision making and resource management. Areas of uniform characteristics are separated into polygons based on a defined set of criteria and vegetated (tree and non-tree) and non-vegetated (land and water) attributes are estimated for each polygon. Field confirmed calibration points assist the photo interpreter in the estimation process. Data is stored in a standardized VRI database format. The definition of the attributes themselves is compatible with information collected by other resource surveys or inventory processes.

The RIC approved standards are the minimum standards for Photo Estimation within Inventory Units or for the Provincial VRI. The RIC standards include protocols for:

- **roll over** of existing information. Where there is an existing photo based inventory and there is no expressed need for new information, the stakeholder can use the existing timber attribute information by translating it to the VRI database;
- **retrofit**(converting the existing inventory to RIC standards). Where the existing photo based inventory is acceptable and there is a need to add other VRI attribute data to the existing timber information, the stakeholder can translate the existing information and add the additional VRI attributes through photoestimation just for the non-timber attributes;
- **new photo estimation**. The stakeholder conducts a new photo estimation to the VRI standards.

5.2. GROUND SAMPLING

The objective of Management Unit and Provincial VRI ground sampling is to provide adjusted attribute values in the photo estimated database and develop statistically defensible overall totals and averages for timber and non-timber vegetation resources. In general, Management Unit Inventory sampling will aim to achieve a sampling error in accordance to the stakeholders' business objectives.

The Provincial VRI ground sampling will aim to achieve a sampling error of $\pm$10% (at the 95% probability level) for net timber volume in the treed portion of the District, and to allow for calculation of sampling errors for other VRI attributes. The Provincial VRI will cover the *entire* District including the timber harvesting landbase, inoperable landbase, parks, recreation areas, ecological reserves and private lands. The key attributes of interest are stand age, net volume by species, stand height and species composition. The variability of these tree attributes will be used to set the sample size for the Provincial VRI.

Table 1 identifies the primary ground sampling tools for a Management Unit Inventory or the Provincial VRI. Complete cards must be filled out depending on the inventory sample type selected. This allows for consistency of data across units and facilitates the incorporation of Management Unit Inventory data into the Provincial VRI database.

For the National Forest Inventory, ground sampling standards will be conducted according to the protocols set out by the Canadian Forest Service. These standards are compatible with the Provincial VRI ground sampling protocols. NFI ground sample plots are located on a grid-based network.

Table 1: Ground Sampling Requirements.
(Refer to RIC approved standards for further details)

	Available Ground Sampling Tools						
	Timber Emphasis	Ecology	Coarse Woody Debris	Range	Provincial VRI	Net Volume Adjustment Factor	WPV
1. CH - Header	✓	✓	✓	✓	✓	✓	✓
2. CP - Compass	✓	✓	✓	✓	✓	✓	✓
3. CL - Cluster Layout	✓	✓	✓	✓	✓	✓	✓
4. RS - Range Sampling - Shrub Transact #1				✓	✓		
5. RT - Range Sampling - Shrub Transect #2				✓	✓		
6. EW - Coarse Woody Debris - Transect #1			✓		✓		
7. EC - Coarse Woody Debris - Transect #2			✓		✓		
8. TD - Tree Details	✓				✓	✓	✓
9. TL - Tree Loss Indicators	✓				✓	✓	✓
10. TS - Small Tree, Stump and Site Tree Data	✓				✓		
11. TA - Auxiliary Tree Card	✓				✓		
12. EP - Ecological Description 1		✓			✓		
13. ED - Ecological Description 2		✓			✓		
14. ET - Tree and Shrub Layers		✓			✓		
15. EH - Herb and Moss Layers		✓			✓		
16. EO - Succession Interpretations		✓			✓		

5.3. NET VOLUME ADJUSTMENT FACTOR

The objective of NVAF is to provide a statistically valid net merchantable volume for the inventory unit. The net merchantable volume for an inventory unit is determined by using two procedures: call grading/net factoring (CG/NF) of standing trees in the ground samples, and Net Volume Adjustment Factor (NVAF) sampling of a sub-sample of felled ground sample trees.

NVAF is a critical component of the VRI design and is a requirement of the Provincial VRI and management unit inventories. If NVAF sampling has not been completed, merchantable volumes may be derived using existing MoF loss factors, however the volumes may be biased. NVAF sampling must be completed.

The NVAF is used to statistically adjust the estimated net volume for an Inventory Unit. It is calculated as a ratio of actual net merchantable volume, which is based on felled tree sampling, to the estimated net merchantable volume, which is based on the CG/NF system and the MOF taper equations. It will correct for possible taper equation error; CG/NF rule error; hidden decay and hidden loss indicators.

NVAF sampling is a two step operation. In the first step, the auxiliary plots of a random sub-sample of VRI plots are cruised using CG/NF methods. In the second step, the cruised trees are loaded into a sampling matrix and a random selection of trees taken from each cell.

The MOF Resources Inventory Branch requires a minimum of 75 sample trees be selected from the timber inventory samples for NVAF stem analysis. This would apply for each Management Unit Inventory as well as for the Provincial VRI. For Management Unit inventories, these sample trees should be selected from 15 polygons; and for the Provincial VRI these samples should be distributed from 15 treed and 1 non-treed polygons. Table 1 identifies the minimum ground sampling requirements for the NVAF.

5.4. Within Polygon Variation

The objective of within polygon variation (WPV) field sampling is to give users a reasonable expectation of the difference they should expect to find when they "check the timber inventory" in the field, as well as an estimate of the actual error of the adjusted polygon database. In addition, it establishes a sampling protocol for measuring polygon error rates for any other resource values. Polygon error will be expressed as percentage difference in the polygon values, except in cases of stands of small average diameter trees where actual (absolute) units may be used.

The WPV process is required for the Provincial VRI. For Management Unit Inventories, it is available for use at the discretion of the stakeholder(s).

5.5. National Forest Inventory

The Canadian Forest Service is currently developing the standards and procedures for the NFI.

6. INTEGRATION OF THE INVENTORY GROUND SAMPLES

6.1. OVERVIEW

Implementing Management Unit Inventories in conjunction with the Provincial VRI and NFI raises the question: *How should the NFI and Provincial VRI be integrated with the management (timber emphasis) inventory schedules?* A proposed approach to integration is outlined below. This approach involves planning the Management Unit, Provincial and National Inventories in advance, and subdividing the Provincial VRI and NFI plots into implementation units. Scheduling of the Management Unit Inventories, Provincial VRIs and NFI would be at the convenience of the stakeholder(s) responsible for each implementation unit. The MOF (assisted by licensees and others, e.g., Parks) would be responsible for sampling the TSAs and the other management units (Parks, private land, and other public lands). The TFL holders or other licensees would assist (with logistics and funding) in the installation of the Provincial VRI and NFI plots in their areas in a manner that fits their schedule.

6.2. IMPLEMENTATION

This approach could be implemented as follows[6]:

1. Develop the polygon database.
2. Determine where the NFI ground samples are located for the entire inventory unit.
3. Plan the VRI ground sampling for the entire inventory unit (one or more Forest Districts). Repeat for the management units as needed.
4. Select a large pool of potential sampling points (e.g., 10,000) for the entire inventory unit.
5. Select both the polygons (developed in 1 above) and the plot locations in the polygons for the inventory unit.
6. Indicate the plot locations on large-scale maps, and load into a GIS. This will allow any group considering sampling for management units to identify the plot clusters within the geographic area where they are considering this work.
7. Select the number of plots required for the Provincial VRI plots and additional plots for the management unit inventory.
8. Divide the District landbase into non-overlapping implementation units.
9. Each group (e.g., TFL holder) to complete plots (management, provincial and national plots) within their respective implementation units according to their schedule.
10. Compile the data from the implementation units.

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[6] Iles, Kim. (Undated). *Vegetation Inventory by Parts. The Logic for Dividing an Inventory into Partial Units, To be Completed by Different Groups or at Different Times.* Contract report for Ministry of Forests, Resources Inventory Branch, Victoria, B.C.

11. Eventually, combine the implementation units and produce a complete inventory for the inventory unit. Within a District this process should span no more than four years. The compilation uses simple stratified sampling methodology.

6.3. Reconciling Estimates

Completion of three inventories for the same area will produce three different estimates for that area. While each estimated total serves a distinct purpose, eventually some reconciliation of the estimates will be required. The appropriate method of combining the estimates is the one that provides the best overall precision in the estimates. The national estimate for an inventory unit will generally be less precise than those based on the provincial inventory. The national and provincial estimates for a management unit will generally be less precise than those based on management inventories. The higher level inventory should not replace the provincial/management inventories, but act as a rough check on the provincial/management level inventories[7]. If the provincial or management inventories contain more samples applied using the same methods as the NFI or VRI, then the national and/or the provincial inventory should be adjusted to reflect the better information from the management unit. In this case the NFI and/or the Provincial VRI must be adjusted to reflect this new information. This reconciliation is valid as long as the standards are consistent across all inventories.

6.4. Use of Existing Data to Identify the Relationship to the Photo Estimated Database and Plot Samples

6.4.1. Overview

Existing data can be used directly in forest management or to augment the management unit, provincial and national inventories in order to improve Photo Estimation. These data include the existing inventory, valuation cruising, silviculture surveys, Terrestrial Ecosystem Mapping, and SIBEC (Site Index - Biogeoclimatic Ecological Classification) surveys. Data from these sources can be used to make the VRI more efficient by improving initial estimates before adjustment.

6.4.2. Direct Use

Existing management unit inventories should continue to be used (unadjusted) for forest management until upgrades to VRI standards are gradually made, provided the user has a reasonable level-of-comfort in the information.

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[7] Resources Inventory Committee. 1995. *Final report from the Vegetation Inventory Working Group on a proposed new inventory*. Recommendation #03, page 33.

6.4.3.Sample Planning

An estimate of the variation among sample plots—the coefficient of variation (CV)—is needed to estimate the sample size required to achieve a target precision. The CV depends on the plot design and the attribute of interest. The best source of information to estimate CV is a preliminary VRI sample from the target population or a similar area. However, when this is not feasible, data from operational cruise samples and inventory audit samples may be used.

Operational cruising can provide estimates for one source of variation in the VRI ground sampling system, but the additional source of variation needed to compute sample size is not addressed. Estimates of CVs from inventory audits can provide data for both sources of variation. However, the inventory audit plot cluster design is different from the VRI design. The inventory audit is based on a well-distributed cluster of 9 plots, whereas the VRI is based on a tight cluster of 5 plots. As well, the cruise and the inventory audit samples are usually restricted to the mature component of the population. Since additional sources of variation needed to compute sample size cannot be obtained from operational cruise-based estimates, the inventory audit data, if available, will probably provide the best information to estimate CVs.

6.4.4.Sample Selection

Existing photo interpreted polygon areas and attribute estimates may be useful in selecting sampling points and estimating population and polygon totals. The attribute estimates, if consistent, may also improve the precision of the estimates of overall and polygon-specific totals or averages. Sample selection is usually achieved through a sorted list of all polygons in the forest inventory database for the District. Lacking the new VRI photo interpretation classification, the Forest Inventory/Planning (FIP) file are being converted to the BC Land Classification Scheme (BCLCS) using a defined conversion process, before the list is compiled.[8] For example, a *lake* in the FIP file would be classified in the BCLCS as *NWW_LA* (non-treed, water, wetland, lake), and *NPBr* would become *VN_ST_* (vegetated, non-treed, tall shrub)[9]. The new file is called a VIFF file.

6.4.5.Efficiency

Information from existing sources can also be used to improve the initial (photo interpretation) estimates before they are adjusted using the ground sampling data. When the existing information is from very reliable sampling, the values from the corresponding polygons would change little during the adjustment

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[8] Resources Inventory Branch. *Vegetation Resources Inventory. Forest Inventory Planning (FIP) file conversion to the BC Land Classification Scheme (BCLCS).* Resources Inventory Branch, Ministry of Forests, Victoria, BC. 2 pages. (Contact: Laurence Bowdige)

[9] Blanks in the BCLCS labels indicate no information is available in the current database to assign a BCLCS label at that level.

process. Accurate (consistent) initial estimates lead to VRI efficiency because, for the same level of precision, the adjustment process requires fewer ground samples than inconsistent estimates. The process of improving the initial estimates may involve direct substitution of the data values, or a preliminary adjustment of the data. These improved initial estimates would still have to be adjusted based on formal ground sampling.

6.5. DISCUSSION

Subdividing the District into implementation units and sampling at the convenience of the groups responsible for the inventory of a specific geographic area provides flexibility in integrating management unit inventories with the Provincial VRI. Where, for example, a TFL covers parts of two Districts, the TFL holder may want to sample the entire TFL at once, and will complete implementation units in each District. The best time to complete the ground sampling may be different for each group involved, and from an administrative and budget viewpoint. However, it is hoped that the stakeholders will complete the installation of the Provincial VRI plots in their jurisdiction within the period prescribed for a District.

7. EXAMPLE: PORT McNEILL FOREST DISTRICT

7.1. OVERVIEW

The Port McNeill Forest District is used to illustrate the integration of the Provincial VRI and the management inventories. **The timber volumes used in this example are hypothetical**.

7.2. LANDBASE

The planned inventory unit for the Provincial VRI in the Port McNeill area is the Port McNeill Forest District. The total area of the District is approximately 2,548,149 hectares and includes the TSA, TFLs (within the District boundaries), and Parks (within the District boundaries) (Table 2).

Table 2 Management units of the Port McNeill Forest District

Management Unit	Area (ha)	Area (%)
Kingcome TSA (incl. Brooks Peninsula and Cape Scott parks)	1,870,000	73.4
TFL 6 (Western Forest Products)	170,213	6.7
TFL 25 (Western Forest Products)	31,300	1.2
TFL 37 (Canadian Forest Products)	190,000	7.5
TFL 39 (MacMillan Bloedel)	68,000	2.7
TFL 43 (Scott Paper)	962	0.0
TFL 45 (International Forest Products)	180,000	7.0
TFL 47 (TimberWest)	37,674	1.5
Total area	*2,548,149*	*100*

7.3. PROPOSED SAMPLING PLAN

Stakeholders in the District have developed a preliminary sampling plan for VRI ground sampling by identifying local inventory needs and priorities[10]. Stakeholders include staff from the MOF (Resources Inventory Branch, Vancouver Forest Region, and Port McNeill Forest District), BC Parks, Canadian Forest Products, International Forest Products, MacMillan Bloedel, TimberWest, Scott Paper, and Western Forest Products. The consultation process included a meeting to identify local forest management and inventory issues, needs, and priorities, and to develop inventory objectives. The sample sizes for the preliminary sampling plan for this District are summarized in Table 3.

Table 3 Preliminary ground sample sizes for the Port McNeill Forest District.

Land Type	Number of sample clusters All VRI measurements[11]	Number of sample clusters Tree emphasis plots only[12]	Total number of sample clusters
National Forest Inventory			
Ground Samples (Grid)	2		2
Provincial VRI			
Vegetated Treed	40	40	80
Remaining Area (Non-Veg.; Veg. Non-Treed)	40	-	40
Sub-total	*80*	*40*	*120*
Management Inventories[13]			
Kingcome TSA	(59)	70 (29)	158
TFLs 6 & 25	(6)	185 (3)	194
TFL 37	(6)	90 (3)	99
TFL 39	(2)	- (2)	4
TFL 43	(0)	50 (0)	50
TFL 45	(6)	85 (2)	93
TFL 47	(1)	- (1)	2
Sub-total	*(80)*	*480 (40)*	*600*

[10] *Port McNeill Forest District. Vegetation Resources Inventory Ground Sampling Plan Preliminary Report* (Resources Inventory Branch, 1997)

[11] Bracketed figures indicate the number of Provincial VRI samples falling within each sub-unit.

[12] Bracketed figures indicate the number of Provincial VRI tree emphasis samples falling within each management unit; unbracketed numbers indicate the number of additional samples needed to increase the precision of volume in each sub-unit to 10% sampling error (95% probability). No additional sample sizes are shown for TFLs 39 and 47 since no management inventories were planned as part of the District sampling plan for these management units.

[13] These management units could correspond to implementation units for the Port McNeill VRI.

7.4. IMPLEMENTATION

In this example, the TSA and the TFLs could be considered implementation units. Each group would install only those NFI and Provincial VRI plots in their implementation unit (alone or in combination with implementation units in other Districts). For example, TFL 47 would install one timber emphasis, one full VRI and TFL 47 NFI plots. The Forest District (and the licensees) would install 29 tree emphasis, 59- full VRI and 0 NFI Plots in the TSA. (Note, the NFI plots would be installed in TFL 37 and in TFL 47).

7.5. COMPILING TIMBER VOLUME

For illustration, Table 4 shows hypothetical timber volumes and associated sampling errors for the District and for the various management units, as if the sampling plan for Port McNeill Forest District had been implemented. Note in this table that the sampling errors for the sub-units based on the Provincial VRI are high. Additional sampling at the management unit level is required to increase precision to the estimates suitable for forest management. For example, the sampling error of the net timber volume in the TSA is 28% (95% probability) based on the Provincial VRI. An additional 70 samples would be needed in the TSA to reduce the sampling error to 10%.

Table 4 Hypothetical volumes in Port McNeill Forest District

Management Unit	Total volume based on Provincial VRI only (m^3 x millions)		Total volume based on Provincial VRI + additional tree-emphasis plots (m^3 x millions)	
National Forest Inventory				
Ground Samples (Grid)	2		-	
Provincial VRI				
Vegetated Treed	40	(10)[14]	-	
Remaining Area (Non-Vegetated; Vegetated Non-Treed)	0		-	
Management Inventories				
Kingcome TSA	29.36	(28)	31.3	(10)
TFLs 6 & 25	3.16	(28)	3.2	(10)
TFL 37	3.00	(40)	3.0	(10)
TFL 39	1.08	(52)	1.6	(10)
TFL 43	0.00		0.1	(10)
TFL 45	2.80	(90)	2.7	(10)
TFL 47	0.60	(127)	0.1	(10)
Total volume	*40*		*42*	

[14] Bracketed figures represent sampling errors (95% probability), assuming a CV of 45% for net timber volume in the treed landbase (Provincial VRI) and in the timber harvesting landbase (sub-units).

The Provincial VRI and management inventories would produce two sets of timber volumes for the District and for each management unit (Table 3). Note that the Provincial VRI would not normally be reported by management unit, only by Region and District. Hypothetical volumes from the Provincial VRI are shown in the first column, and volumes from the management inventories (the Licensee's localized inventory) are shown in the second column. The hypothetical total volume for all the management units is 42 million cubic metres, whereas based on the Provincial VRI, the volume is 40 million cubic metres. In this case, the management inventories would not be adjusted, but the provincial estimate would be adjusted to 42 million cubic metres to reflect the higher sampling intensities and higher overall precision of the management units.

8. BUSINESS NEEDS AND INVENTORY PLANNING

8.1. BUSINESS NEEDS

The VRI baseline data and information is important for land planning and forest management. Priority forest management issues need to be identified by the stakeholders for a given area. An assessment of inventory solutions to meet business needs is then required. The resulting information needs to be documented within an Inventory Plan. The Inventory Plan[15] is intended to provide more detailed information to the Ministry of Forest's, and Forest Renewal BC regarding the identified Vegetation/Timber Inventory.

It is intended that the Inventory Plan be signed-off by the Director, MOF Resources Inventory Branch, the Regional Manager and the stakeholder(s).

8.2. PURPOSE

The Management Unit and/or VRI Inventory Plan outlines a strategy for completing the inventories (Management Unit Inventory, Provincial VRI and NFI) across a particular unit. The plans are developed through consultation with various stakeholders in the area including the Ministry of Forests, Branch, Region and District staff, Licensee staff who identify inventory local needs and priorities, the Ministry of Environment, Lands and Parks, Non-Government Organizations, First nations, Contractors and the public. Management issues identified in the recent timber supply review in the TSA also need to be reviewed.

[15] For this report. "Inventory Plan" refers to timber emphasis or the Provincial VRI inventories.

8.3. OBJECTIVES

The objectives of the Inventory Plan are to:

1. define the Provincial VRI strategy for a defined unit (e.g. TSA, TFL, Management Unit)
2. define the Management Unit inventory objectives;
3. identify the National Forest Inventory Plot locations and requirements;
4. identify the inventory activities required to satisfy the objectives for all inventories; and
5. outline the implementation steps.

8.4. MILESTONES AND RESPONSIBILITIES

For a Management Unit Inventory or a Provincial VRI to be conducted, the following table (Table 5) outlines the possible milestones and associated responsibilities for implementation of the inventory.

Table 5 Milestones and responsibility for Inventory Implementation

Milestones	Responsibility
Ground Sampling	
First Field Season - 1997	
• Obtain Provincial VRI sample cluster information from the Resources Inventory Branch	Resources Inventory Branch (RIB)
• Assemble and sort all District polygons	RIB
• Select a large number of potential sampling points from list	RIB
• Select first year sample clusters from list	Stakeholder/RIB
• Plan for field sampling	Stakeholder
• Operational Support of Package Preparation	MOF Region
• Prepare field sampling plan with plot locations	Stakeholder
• Determine IPC Locations	MOF Region
• Locate and measure sample clusters	Stakeholder
• Operational Support of Field Sampling	MOF Region/Stakeholder
• Monitor QA of field data and procedures	MOF Region, Stakeholder
• Compile data from completed batches	Stakeholder/RIB
• Review data and reconcile Coefficient of Variation, Sampling Error and Sample Size estimates	Stakeholder/RIB
Second Field Season – 1998	
• Locate and measure sample clusters (measuring only some tree attributes and site series)	Stakeholder
• Operational Support of Field Sampling	Stakeholder/MOF Region
• Monitor QA of field data and procedures	Stakeholder/MOF Region
• Compile data from completed samples	Stakeholder/RIB
Net Volume Adjustment Factor	
• NVAF Ground Sample Selection	RIB
• Capture Auxiliary Plot Data	Stakeholder
• Validate Auxiliary Plot Data	MOF Region
• Select Trees	RIB
• Capture Stem Analysis Sample Data	Stakeholder
• QA Stem Analysis Sample Tree Data	RIB
• Compile Cruisers Standing Net Volume	RIB

• Compile Stem Analysis Sample Data	RIB
• Calculate NVAF	RIB

New Photo Estimation	
• Develop Technical Plan	Stakeholder
• Evaluate Technical Plan	Stakeholder, MOF Region/RIB
• Delineate and Interpret Aerial Photos	Stakeholder
• Capture and Validate Data	Stakeholder
• Digitize Photos	Stakeholder
• Integrate Data (i.e. Ancillary Data)	Stakeholder. MOF Region
• Derive Slope, Elevation and Aspect	Stakeholder
• Derive Additional Attributes	Stakeholder
• Debriefing of Ministry of Forests	Stakeholder, MOF Region, RIB

Adjust	
• Identify Adjustment Relationships	RIB
• Adjust Photo Estimation Data	Stakeholder
• Review/Sign-off Adjustment	RIB

Report	
• Prepare Report for Management Unit Inventory	Stakeholder

9. CONCLUSIONS

This paper has discussed Management Unit Inventories, the Provincial VRI, the National Forest Inventory, and the integration of these inventories. The inventory unit for a management inventory is an entire or partial management unit. The stakeholders (e.g., TFL holder, Parks, or Forest District) define the management unit. The inventory unit for the Provincial VRI is one or more Forest Districts, as defined by the MOF, Resources Inventory Branch.

Each level of inventory has specific objectives. Management Unit Inventories are the responsibility of the TFL holders and Districts to provide detailed polygon information for day-to-day forest management business. These inventories would also be used to increase precision of the provincial inventory, by gradual integration into the provincial inventory in an unbiased way. However, the MOF should request that TFL holders prepare an inventory business plan for approval. The Provincial VRI is a provincial responsibility that is expected to provide data for reporting, monitoring, research, and baseline data to address credibility and public relations issues relevant to the forest industry in BC. It also would reduce the pressure on the TFL holders to provide data for roll-up to the provincial level.

It is hoped, that in conjunction with the Management Unit Inventories, the Provincial VRI and NFI ground sampling, at minimum, be completed. This would involve planning of the Management Unit, Provincial and National inventories in advance through Implementation Plans. The Implementation Plans would outline the business requirements for the inventory and a strategy for fulfilling those requirements.

Each Management Unit Inventory would be allocated an appropriate number Provincial and National inventory plots based pre-defined selection criteria. Scheduling the completion of the inventories would then be done at the convenience of the groups responsible for each implementation unit. The MOF (assisted by licensees) would be responsible for installing the provincial plots in the TSAs and other lands (Parks, private land, etc.). The TFL holders would assist in the installation of provincial plots in their TFLs in a manner that fits their own schedule. This approach provides flexibility in terms of administration, funding, and timing, and does not require changing the definition of the Provincial VRI inventory unit (one or more Forest Districts).